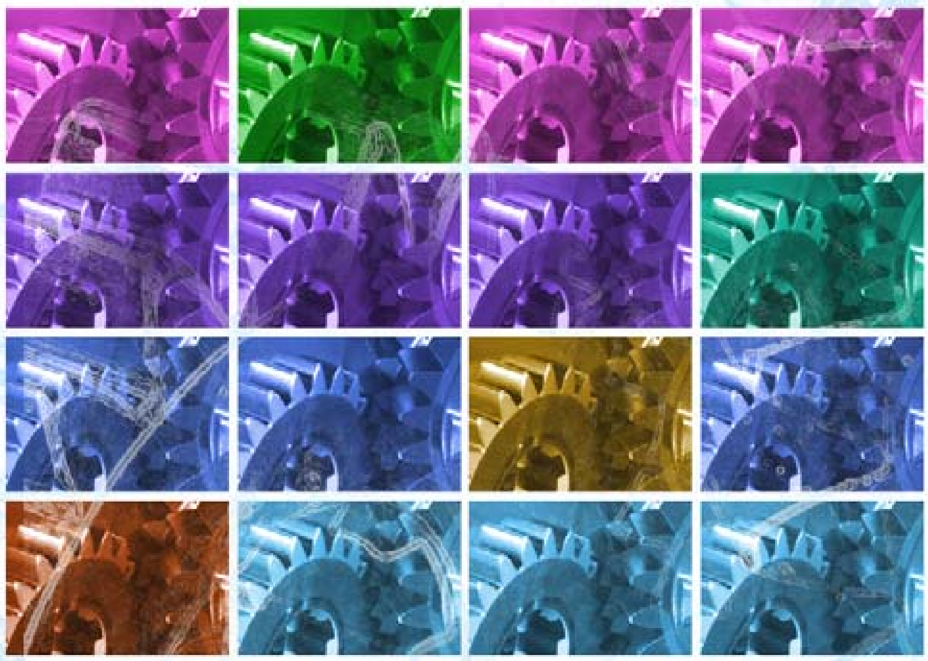
Programs

Programs @ a Glance



Advanced Optics Metrology

Program Manager:	Bob Polvani
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FTEs:	3.0
Program Funding:	$556 K

Program Goal

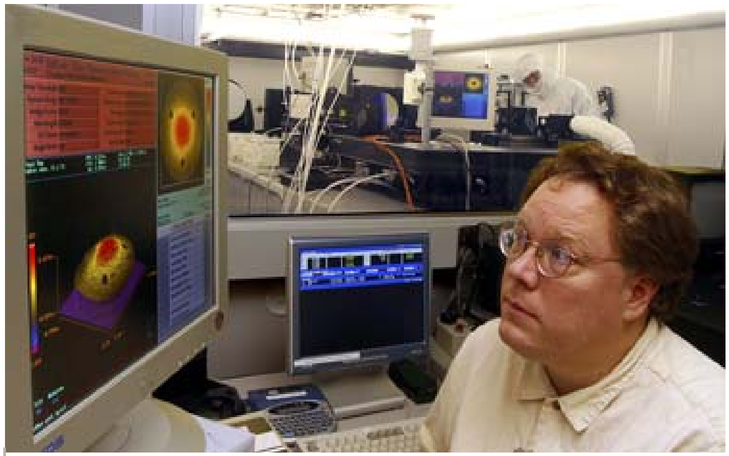
Develop and provide NIST measurement services for flatness, radius of curvature, and optical figure with Systeme Internationale d'Unites (SI) traceable expanded uncertainties of 0.25 nm rms or better over apertures up to 300 mm for the optics, microelectronics, and data storage industries.

Problem

Current measurement technology is increasingly inadequate to meet the geometrical tolerance requirements of ultra-precise optics with aspheric surfaces, such as optical elements and semiconductor substrates for fabricating next-generation micro-electronics and optoelectronics. Even modeling of the optical performance of critical elements is limited by the inability to measure parameters such as radii of curvature. There are currently no standard test methods or NIST measurement services to meet these needs.

Approach

We are implementing a new measurement capability, known as the NIST X-ray accurate optics CALIBration InterferometeR (XCALIBIR). XCALIBIR's ultra-high resolution and our interferometer capable of operating at infrared wavelengths provide a combined capability to measure optical figure as well as subsurface damage and thickness variations of semiconductor wafers.



XCALIBIR's ultra-high resolution and our interferometer capable of operating at infrared wavelengths provide a combined capability to measure optical figure as well as subsurface damage and thickness variations of semiconductor wafers.

Customers and Collaborators

- ASML/Tinsley
- Kansas State University
- Komatsu
- MEMC
- Microelectronics, data storage, and optics defense system supplier industries
- NASA
- Optimax Systems
- Taylor Hobson, Ltd.
- University of Northern Carolina
- Virginia Semiconductor
- Wavefront Science

Critical Infrastructure Protection

Program Manager:	Fred Proctor
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FTEs:	1.5
Program Funding:	$433 K

Program Goal

Increase the security of computer systems that control production and distribution in critical infrastructure industries, including electric power, oil and gas, water, chemicals, pharmaceuticals, metals and mining, pulp and paper, and durable goods manufacturing by (1) defining and applying standard information security requirements, (2) developing information security best practice guidelines and conducting outreach activities, and (3) developing laboratory and field test methods for information security products and approaches applied to the process control sector.

Problem

The computer systems that control industrial production and distribution have been designed first and foremost to meet performance, reliability, safety, and flexibility requirements. Yet these systems increasingly incorporate connectivity and remote access capabilities. Industry has begun to appreciate that increased connectivity and openness are introducing serious vulnerabilities into operational systems. One critical problem of immediate concern is the absence of methods to specify and verify the security characteristics of control system components and networks. These are problems that the Common Criteria for Information Technology (IT) Security Evaluation, developed by NIST and the National Security Agency (NSA), are intended to address.

Power plants such as this form the nation's critical infrastructure. Securing them against cyberattack is a top priority.

Approach

To develop IT security requirements for industrial control systems, NIST is working with industry through its leadership of the Process Control Security Requirements Forum (PCSRF). Through the PCSRF, the following steps are being taken to develop process control information security requirements:

- analyze currently available computer control system architectures, including analysis of threats and vulnerabilities;
- develop information security requirements, in language and format understandable to the process control users and vendors; and
- translate Information Security Requirements into Common Criteria Protection Profiles that can be used to enable testing and evaluation of covered computer control system products/systems by accredited IT security testing laboratories.

Customers and Collaborators

- American Gas Association
- American Water Association
- Dow Chemical
- Dupont Chemical
- Gas Technology Institute
- Georgia-Pacific
- Instrumentation Society of America
- KEMA Consulting
- Maximum Control Technology, Inc.
- U.S. Department of Energy

Engineering Metrology

Program Manager:	Ted Doiron
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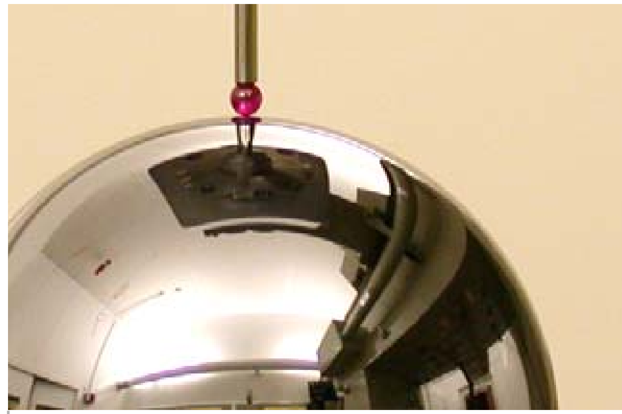
FTEs:	8.2
Program Funding:	$1.3 M



Silicon sphere fixtured on M48 CMM.

Program Goal

Provide world-class engineering metrology resources for our customers to promote the health and growth of U.S. discrete-parts manufacturing by delivering significantly improved, state-of-art uncertainty levels for industry-critical measurement services; reducing calibration turn-around time and increasing percentage of calibrations completed on time in key calibration areas; and developing new measurement techniques to meet emerging industry needs.

Problem

The Engineering Metrology Group has the largest dimensional measurement customer base of any NMI in the world, perhaps by an order of magnitude. This program allows US industry unparalleled access to state-of-the-art measurements by providing very high accuracy and high throughput services. Improved service to our customers will enhance U.S. ability to compete in world markets, and new competencies will provide opportunities for U.S. industry to grow and compete.

Approach

This program takes a broad approach to improving all aspects of Engineering Metrology services to industry based on delivery of high-quality measurement services with increased efficiency, coupled with research into new measuring methods. For the small hole area, we plan to expand our capabilities for industry-needed measurements of small, high-relief structures (such as 125 mm holes), with nano-force probing. In the grid plate area, we will demonstrate world-class (sub-100 nm uncertainty) 2-D video-based CMM measurements on M48 CMM and will provide materials (grid SRM) needed to improve 2-D metrology in semiconductor manufacture. The Dilatometer project will provide industry with the needed thermal expansion coefficients of characteristic, key artifacts, measured with new system for high-accuracy dilatometry. We will develop systems for state-of-art cylindrical form measurement.This year, we will begin final implementation of the new systems for gage block and sphere calibration needed to improve calibration efficiency by reducing number of needed master artifacts. Over 200 companies rely on us for calibrations, and a much wider audience is interested in the information and techniques that we develop. Our customers are important and we address their needs through technical meetings, information on our web site, training courses in dimensional metrology, collaborating with graduate students and guest researchers, and CRADAs with private industry. We calibrate over 5000 artifacts each year, providing a traceable link to the definition of the meter for more than 160 organizations in 40 states.

Customers and Collaborators

- Aerospace Industry
- Automotive Industry
- Heavy equipment Industry
- Telecommunication industry
- Measuring tool and machine tool industries

INTEGRATED NANO-TO-MILLIMETER MANUFACTURING TECHNOLOGIES

Program Manager:	Kevin W. Lyons
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FTEs:	6.0
Program Funding:	$880 K

Program Goal

Address the anticipated needs of the emerging U.S. nanotechnology industry; develop and deliver models, architectures, and methods for process measurement and control systems that enable manufacturing across nm-to-mm scales.

Problem

Major industrial and scientific trends that emerged during the 1990s will influence not only how manufacturing will be done over the next decade, but also what is manufactured. The size of many manufactured goods continues to decrease, resulting in ultra-miniature electronic devices and new hybrid technologies. For example, microelectromechanical systems (MEMS) devices integrate physical, chemical, and even biological processes in micro- and millimeter-scale technology packages. MEMS devices now are used in many sectors: information technology (IT), medicine and health, aerospace, environment, and energy to name a few. On the horizon is the development of nanomanufacturing technologies that will support tailor-made products having functionally critical nanometer scale dimensions produced using massively parallel systems or self-assembly. There is a need to develop advanced models, new architectures, and innovative methods for process measurement systems that will serve as enablers for the US nanotechnology industry and as a foundation for standards that support this emerging market.

Program will develop models, architectures, and methods that support improved human-computer interfaces for controlling complex instruments.

Approach

The research effort is comprised of three thrusts; 1) atomic-scale manufacturing, 2) molecular-scale manipulation and assembly, and 3) micro-to-millimeter scale manufacturing technologies, each focused on a specific application area and problem set. Each of the thrust areas will address unique aspects regarding the development of models, architectures, and methods. Throughout all phases of the program, the knowledge learned in each of the thrust areas will be shared with the others to maximize the outcomes of the program.

Customers and Collaborators

- SEMATECH
- Johns Hopkins University Applied Physics Laboratory
- Massachusetts Institute of Technology
- NASA Goddard Space Flight Center
- Penn State University
- Purdue University
- Rensselaer Polytechnic Institute
- University of Maryland, College Park
- Washington State University – Virtual Assembly Technologies Consortium

Intelligent Control of Mobility Systems

Program Manager:	Maris Juberts
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FTEs:	10.0
Program Funding:	$3.0 M

Program Goal

To provide architectures and interface standards, performance test methods and data, and infrastructure technology needed by U.S. manufacturing industry and government agencies in developing and applying intelligent control technology to mobility systems to reduce operational costs, improve performance and safety, and save lives.

Problem

Customers have a variety of measurement and standards needs. To develop and use intelligent mobile systems, industry and government agencies need architectures and interface standards to ensure interoperability, real-time sensing technologies for measurement and control, and metrics for evaluating the performance of components and systems.

Approach

The Intelligent Control of Mobility Systems Program will provide industry with standards, performance metrics, and infrastructure technology to broaden the use of advanced perception and autonomous navigation techniques; provide defense agencies with the control system architectures, advanced sensor systems, research services and standards to achieve the use of unmanned ground vehicles in the battlefield; provide the evaluation and measurement methods, testing procedures, standard reference data needed to support the deployment of advanced technology in transportation and industrial safety systems, and in future combat systems.

The program will use the NIST Real-time Control system (RCS) architecture as an example of an open system architecture for building complex autonomous robotic systems for other government agency programs and funds and then invest direct appropriations to transfer relevant advanced robotics technology to industrial applications.

Customers and Collaborators

- Advanced Scientific Concepts
- Army Research Lab
- Boeing
- Carnegie Mellon University (CMU)
- Coherent Technologies
- Daimler Chrysler/Dornier
- Defense Advanced Research Projects Agency (DARPA)
- Department of Transportation-National Highway Traffic Safety Administration (DOT-NHTSA)
- Drexel University
- GDRS
- General Dynamics
- Jet Propulsion Lab
- John Deere Co.
- Lockheed Martin
- Raytheon
- Sandia National Lab
- Science Applications International Corporation (SAIC)
- The Ohio State University
- Universitat der Bundeswehr/Munich
- University of Maryland
- Transbotics Inc.
- University of Delaware
- Bremen University/ Germany
- TACOM

Intelligent Open Architecture Control

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FTEs:	6
Program Funding:	$1.5 M

Program Goal

Develop and validate key interface standards, and conformance tests for those standards, to achieve interoperability among control systems for machines on the factory floor and between these systems and design and planning systems, as well as factory data networks.

Problem

Over the past two decades, information technology has dramatically increased the intelligence of the upper levels of manufacturing systems. In the next 20 years, this intelligence will reach down to the factory floor as individual machines become much smarter, more easily integrated, and able to communicate more broadly, predict results and avoid or diagnose mistakes, use extensive in-process gaging, and use scientific models to optimize productivity.

These trends, echoed in the Integrated Manufacturing Technology Roadmap (IMTR, now known as the Integrated Manufacturing Technology Initiative [IMTI]), have great potential to decrease time and cost to market, improve quality, and increase productivity. However, they require a seamless flow of information and total integration throughout the enterprise, and today, in the words of one industry workshop attendee, “all the links are broken.”

The lack of interoperability costs U.S. industry billions of dollars. A typical robot installation costs 3 to 5 times the actual cost of the robot (1999 Robotics Industry Forum). The aerospace industry also cites similar data: $10 million of capital equipment can take as much as 100 person years to integrate. (Boeing data)

Approach

The program seeks to realize interoperability by facilitating and participating in industry efforts to standardize open architecture control—a common architecture of system components and interfaces—which is the key to connecting systems and realizing the benefits of increased intelligence in manufacturing. Program staff hold workshops, in collaboration with industry and government agencies, to identify the most pressing interoperability problems; facilitate and participate in industry efforts to develop suitable architectures as a basis for interface specifications; establish testbeds with real manufacturing equipment to implement and test candidate specifications; and, in cases where conformance tests are needed to ensure interoperability, work with industry to develop them.

The program is intended to accelerate the implementation and commercial availability of controllers with advanced capabilities, and to reduce controller life cycle costs due to easier integration of controller components and increased competition among controller component vendors. This benefits U.S. controller vendors and users differentially by helping them to gain a competitive advantage in implementing and applying advanced capabilities at lower costs.

Customers and Collaborators

- Automotive Industry Action Group
- Instrumentation Society of America
- Metrology Automation Association
- Open DeviceNet Vendors Association
- Open Modular Architecture Controller Users Group
- Robotic Industries Association

LARGE SCALE METROLOGY

Program Manager:	Steven D. Phillips (Acting)
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Program Funding:	$501 K

Program Goal

Provide U.S. large-scale-manufacturing metrologists with the tools—standards, artifacts, and methodologies—for characterizing the performance of coordinate measuring systems.

Problem

In general, traditional large scale coordinate measuring machines (CMMs) collect sparse, discrete-point coordinate data; the output of these systems is often used to characterize the size, shape, and orientation of simple geometric elements. The latest large scale coordinate measuring systems (CMSs) collect dense clouds of data, with the intent of characterizing large, free-form complex surfaces. Users need to know the uncertainty associated with the measurements made by these systems both in support of manufacturing and for intercomparison of like instruments. Conventional artifacts are inadequate for evaluating the performance of these systems. Moreover, the software used to fit raw measurements to geometric representations of a workpiece tends to compound the uncertainty problem. Users and vendors seek objective analytical methods and tools as well as a neutral test service to assess the uncertainty of the measurement results.

Large Scale Coordinate Metrology Group members discuss methods to measure complex geometries.

Users (Boeing, the Propulsor Group of the Naval Surface Warfare Center (NSWC), Large Millimeter Telescope group (LMT)) and equipment manufacturers (Dimensional Photonics, Automated Precison Inc., Imetric SA) have expressed orally and in writing both their need for NIST services and their great concern over the critical lack of a research base in these areas.

Approach

The problem is being addressed through standards development, methodology research, artifact development, and software testing.

Customers and Collaborators

- Aerospace Industry
- Automated Precison Inc.
- Boeing
- Caterpillar
- Dimensional Photonics
- Imetric SA
- Large Equipment Manufacturers
- Large Millimeter Telescope group
- Propulsor Group of the NSWC
- Shipbuilding Industry

MANUFACTURING ENTERPRISE INTEGRATION

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Program Funding:	$1.6 M

Program Goal

Demonstrate a cost reduction for Business-to-Business (B2B) software integration using new types of semantics-based measurements, standards, and infrastructural technologies that automate the process of integration

Problem

The Internet is a critical part of the e-business strategy of most manufacturing enterprises. Internet communication standards govern the exchange of bits and bytes from one computer to another. It enables manufacturers to link up with global partners, suppliers, and customers.

The Internet, however, is not enough. To turn business possibilities into realties, users require the integration of business-to-business (B2B) software applications that exchange information objects using the Internet. A number of national and international standards bodies have developed (1) specifications that define these objects and (2) protocols for the messages that carry them.

U. S. manufacturers and the software vendors are facing tow major problems. First, multiple, competing B2B standards are emerging that lead to incompatible software solutions. Second, the adoption of different, possibly regional, B2B standards in places like Europe and Korea will lead to multiple e-business requirements for U.S. companies.

Approach

We developed an operational strategy for the AMIS (Automated Methods for Integrating Systems) project, which is developing tools and methods to automate the process of software integration. We are using emerging enterprise-modeling techniques to capture interaction ontologies – the business entities and functions involved in the integration task. We are developing software-modeling techniques to capture implicit ontologies – the objects and information a component deals with and the functions it performs. We will convert the models to forms suitable for processing by artificial intelligence techniques. We will use semantic-analysis techniques to develop mappings between the implicit ontologies and the interaction ontology. And, we will use knowledge bases, expert-systems, and code-generation techniques to generate runtime tools that implement the semantic mappings by converting messages between components.

We continued development of the B2B Interoperability Testbed, which provides an infrastructure for interactions among manufacturers, standards organizations, and software vendors. Manufacturing companies provide integration scenarios. Standards organizations provide specifications that cover all aspects of interoperability. Vendors use the tesbed, scenarios, and specifications to assess, analyze, measure, and demonstrate on-demand integration of their software products. We give guidance for coordination of interactions, develop conformance test, provide test data, and conduct interoperability tests.

Customers and Collaborators

- Automotive Industry Action Group
- Boeing
- Lockheed Martin
- General Motors
- Managing B2B
- Open Applications Group
- University of Maryland
- Postech University

MANUFACTURING SIMULATION & VISUALIZATION

Program Manager:	Charles McLean
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FTEs:	8.0
Program Funding:	$727 K

Program Goal

Establish an initial set of standard interfaces and testing capabilities to enable distributed manufacturing simulation and advance the interoperability of simulation systems and related software applications.

Problem

Simulation technology holds tremendous promise for reducing costs, improving quality, and shortening the time-to-market for manufactured goods. However, this technology remains largely underutilized by industry today. A number of factors inhibit the deployment of simulation technology. For example, no industrial standards organization is focusing on the development of manufacturing simulation standards. Interface standards could reduce the expenses associated with technology acquisition and deployment, minimize model development time and costs, and provide new types of simulation functionality that are not available today. NIST expects to play a major role in helping industry implement simulation and virtual manufacturing technology through the development of interface standards.

Prototype shipboard firefighting simulation-based training application developed for the Naval Education and Training Command.

Approach

We are working with industry, academia, and other government agencies to identify interoperability requirements for simulation. Our current efforts are focused on the specification of data models and interfaces for integrating manufacturing simulation systems with other applications in a machine shop environment. A prototype generic machine shop simulator is under development for use in evaluating the feasibility of proposed interface standards. The results of this work will be made available to a wide variety of machine shops through the Software Engineering Institute's Technology Insertion Development and Evaluation (TIDE) Program. NIST staff are promoting the results of this project as candidate neutral interfaces within manufacturing industries, and the simulation software and standards communities.

Customers and Collaborators

- Aerospace Industry
- Automotive Industry
- Industrial Equipment Industry
- Machine Shops
- Mechanical Products Manufacturing Industry
- Semiconductor Industry
- Simulation Software Vendors
- Standards Development Community
- Simulation-Based Learning Community

MECHANICAL METROLOGY

Program Manager:	David J. Evans
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FTEs:	10
Program Funding:	$2,560 K

Program Goal

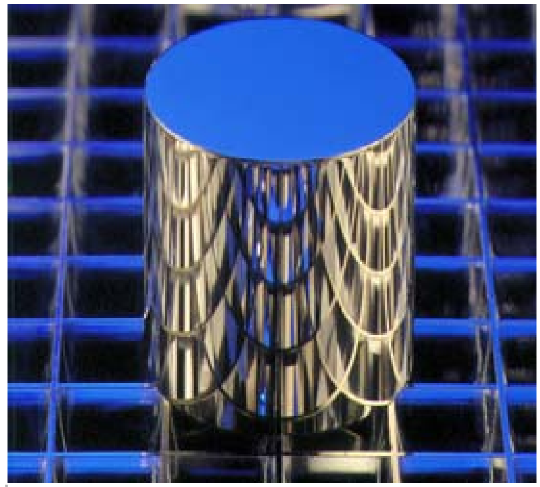
Provide full institutional support to realize, disseminate, maintain, standardize, and improve the realization of the mechanical quantities of acoustics, force, mass, and vibration.

Problem

To achieve efficiency in commerce and ready access to foreign markets, U.S. industry needs measurements of mechanical quantities that are traceable to the appropriate national and international standards. Industry therefore requires internationally recognized calibration services that support mechanical quantities, as well as a means of maintaining international equivalence of measurement services, recognition of calibration certificates and measurement capabilities, and acceptance of test and calibration methodologies.

Approach

NIST, the internationally recognized National Measurement Institute of the U.S., represents U.S. interests on the International Committee of Weights and Measures (CIPM) and its consultative committees and on Regional Metrology Organizations in the Americas.



U.S. National Prototype Kilogram maintained by the Mechanical Metrology Program.

This program realizes, maintains, disseminates, and improves the national physical standards for mechanical quantities. The program also establishes the equivalence and standardizes the realization of these quantities through participation in international and regional metrology organizations and in international and national documentary standards development organizations.

Customers and Collaborators

- Aerospace Industry
- Automotive Industry
- Construction Industry
- Nuclear Power Industry
- Pharmaceutical Industry
- Instrument Manufacturers
- University Research Labs
- State Weights and Measures Labs
- Federal Agencies - Dept. of Agriculture, Dept. of Commerce, Dept. of Defense, Dept. of Energy, Dept. of Labor, Dept. of Veterans Affairs, Dept. of Justice, and the Food & Drug Administration

Nanometer-Scale Metrology

Program Manager:	John Kramar (Acting)
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FTEs:	8
Program Funding:	$2,242 K

Solving the advanced metrology needs of the semiconductor industry allows rapid application of nanometer-scale technology into other industrial sectors.

Program Goal

Provide the needed nanometer-scale metrology infrastructure, traceability, and application-appropriate techniques to foster the development and advancement of U. S. nanotechnology-based and microelectronics industries.

Problem

Emerging nanotechnology-based industries, and established microelectronics and other advanced industries, need measurement methods and artifacts whose dimensions are known with nanometer-scale accuracy, traceable to the internationally-defined unit of length. Of these industries, the strongest push and clearest direction is provided by the ever-advancing needs of the semiconductor manufacturing industry. These are identified, for example, in the *International Technology Roadmap for Semiconductors*. Nanometrology developed for semiconductor applications can be rapidly leveraged by other industrial sectors as the applications develop.

Approach

Length measurements in the nanometer scale regime are accomplished by a number of measurement techniques including tunneling, atomic-force, electron, and visible and ultraviolet light microscopes. These probes are combined with displacement measuring interferometers for accurate length metrology. Computer modeling is an integral part of the process to determine the correspondence between the image or intensity profile and the actual shape and size of the physical object. Calibration artifact and documentary standard development are also key activities. Our research and development focuses on technologies that have the potential to have far reaching effects. Current examples include the development of intrinsic standards that use the atomic lattice as a base; examining high-pressure/environmental microscopy and nano-tip emitters for scanning electron microscopy; fabrication of sub-50 nm calibration structures using unique lithographic techniques, and exploring the applicability of optical microscopy, with modeling, for measuring sub-50 nm features.

Customers and Collaborators

- Applied Materials Inc.
- Argonne National Labs
- Dupont Photomasks Inc.
- E. Fjeld Co.
- EDAX, Inc.
- Hewlett-Packard Co.
- Hitachi High-Technology Corp.
- International SEMATECH
- Intel Corp.
- IBM Corp.
- KLA-Tencor Corp.
- Naval Research Laboratory
- Photronics, Inc.
- Soluris Inc.
- SEMI
- Semiconductor Research Corporation
- Spectel Research Corp.
- UNC Charlotte
- University of Akron
- University of Maryland
- University of South Florida
- University of Tennessee/Oak Ridge Natl. Labs.
- FEI Co.
- VLSI Standards Inc.
- XEI Scientific
- Zyvex Corp.

PREDICTIVE PROCESS ENGINEERING

Program Manager:	Robert W. Ivester
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FTEs:	9.5
Program Funding:	$1.6 M

Program Goal

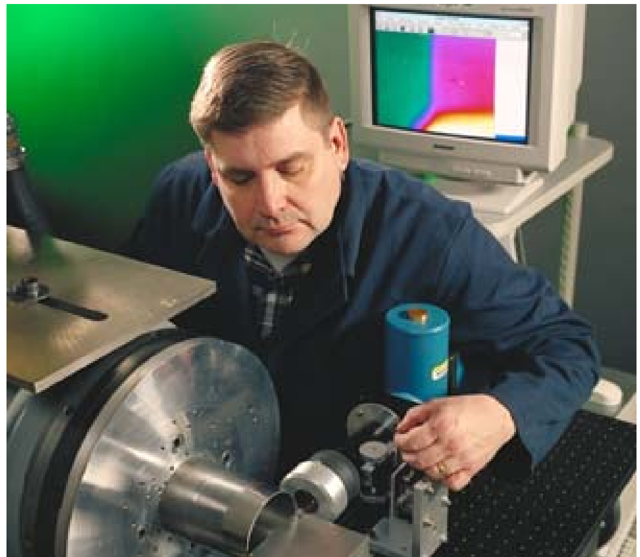
Establish an integration framework for sharing predictive knowledge about machining processes and resources with engineering and control systems using a standard semantic-based process representation and validated physics-based models for milling and turning.

Problem

Manufacturing process parameters, such as machining speeds, feed rates, and tool selection, are typically chosen by costly, trial-and-error prototyping, resulting in solutions that are often sub-optimal. There are two principal barriers to reductions in manufacturing process inefficiencies: lack of access to validated, physics-based models of the manufacturing processes when key engineering decisions are made; and lack of simple mechanisms to enable exchange of process information among manufacturing systems.

Approach

The program will build a foundation for "first part correct" manufacturing based upon a science-based understanding of material removal processes, advanced process metrology methods, validated analytical models to predict process performance and optimize manufacturing decisions, and rigorously-defined representations for manufacturing process information. Program results will be integrated and demonstrated through a prototype integration framework for sharing predictive process knowledge.



Measuring temperature distribution at the tool/workpiece interface helps develop and validate mathematical models of the cutting process.

Customers and Collaborators

- Alcoa
- Boeing
- Caterpillar
- Ford
- General Motors
- Knowledge Based Systems Inc. (KBSI)
- Naval Surface Warfare Center
- Oak Ridge National Laboratory
- Third Wave Systems
- U.S. Army Picatinny Arsenal
- University of Florida
- University of Maryland
- University of North Carolina at Charlotte

PRODUCT ENGINEERING

Program Manager:	Ram D. Sriram
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FTEs:	9
Program Funding:	$1077 K

Program Goal

Establish a semantically based, validated, product representation scheme as a standard that supports the seamless interoperability among current and next-generation computer-aided design (CAD) systems and between CAD and other systems that generate or use product data to help the manufacturing industry achieve a 10% reduction in interoperability costs and a tenfold improvement in design exploration capability.

Problem

A major problem with the emergence of various heterogeneous CAD systems is the lack of interoperability among them. Interoperability problems cost the U.S. automotive supply chain at least $1 billion per year, according to a 1999 RTI International study; other industries are in similar predicaments. This problem has significant implications for the costs at all design stages and overall product cost, because decisions made during the design stage determine 70 percent of a product's cost over its life.

Approach

This program's activities and efforts range from specification and standards development to technology development and prototype implementation. The program is intended to provide the foundation to support the creation of next-generation product development tools, thereby increasing the efficiency, effectiveness, capability, and productivity of U. S. industry.

The primary objectives are to (1) extend the capabilities of ISO 10303 (Standard for the Exchange of Product Model Data, or STEP) by the provision of new resources allowing the capture and exchange of parametric, constraint-based and feature-based models; (2) develop standard representation and protocols for exchanging assembly and system-level tolerance information to enable semantic interoperability between design and manufacturing software systems, including immersive environments; (3) develop and publish an information modeling framework based on a semantically rich core product representation for the support of close integration of design and analysis activities throughout the design lifecycle of an artifact; (4) generate an information model - based on ISO STEP - for representing heterogeneous material data to improve data transfer capabilities from CAD to rapid prototyping/layered manufacturing (RP/LM) systems; (5) define knowledge representation schemes that support the entire product lifecycle; and (6) propose a standards-based framework for modeling information and knowledge in embedded systems design, including hardware/software co-design methodologies.

Customers and Collaborators

- Advanced Technology Institute
- American Society of Mechanical Engineers
- Boeing
- Carco Electronics
- Carnegie Mellon University
- George Washington University
- IBM
- ISO
- KAIST (Korea)
- Nihon Unisys (Japan)
- Object Management Group (OMG)
- Stanford University
- Syracuse University
- Thar Designs
- University of Maryland
- University of Michigan
- University of Wisconsin-Madison
- Washington State University

SHOP FLOOR AS AN NMI

Program Manager:	Steve Phillips
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FTEs:	2.0
Program Funding:	$497 K

Program Goal

Enable the U.S. industrial dimensional metrology community to assert measurement traceability to the Systeme Internationale d'Unites (SI) unit of length.

Problem

The globalization of the economy is strongly driving national and international quality assurance and accreditation programs such as ISO 9000 and ISO 17025, as a means of assuring quality control of components fabricated throughout the world. Most of these standardization and accreditation programs require traceable measurements and hence measurement uncertainty statements. Consequently, U.S. industry is under new pressures to comply with these requirements while being stymied by a poor understanding and incomplete development of measurement uncertainty and traceability issues.

Approach

This program seeks to provide a set of documentary standards, guidelines, and reports to develop and elucidate metrological traceability and measurement uncertainty for dimensional metrology. Additionally, the program seeks to address specific problematic sources of uncertainty and conduct research to characterize these sources in a manner compliant with national and international standards.

The rapid rise in laboratory accreditation programs over the last decade.

Customers and Collaborators

- Boeing
- Caterpillar
- Hutchinson Technology
- Mitutoyo America
- Physikalisch-Technische Bundesanstalt (Germany)
- U.S. Air Force

SMART MACHINE TOOLS

Program Manager:	Johannes A. Soons
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FTEs:	4.25
Program Funding:	$780 K

Program Goal

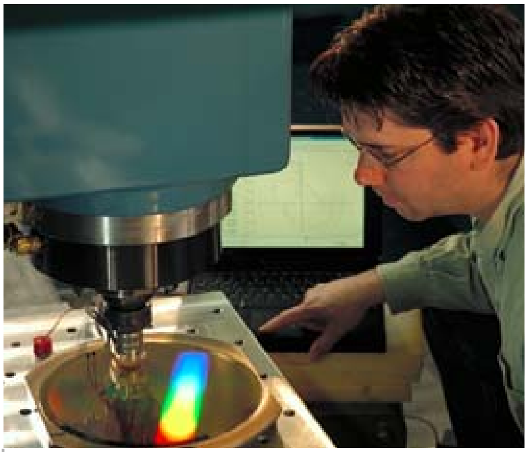
Develop metrology and standards to enable a machining or turning center to provide intelligent feedback on the health of its components and the tolerances it realizes, while autonomously invoking maintenance or tuning operations needed to continue producing the first and every part to specifications.

Problem

Machine tools are the key tools for discrete part and tooling fabrication. Improvements in these machines have a highly leveraged impact through gains in productivity and product quality. Users of machine tools need to deal with ever-more complex parts, closer tolerances, shorter lead-times, and smaller batch sizes. To succeed they need accurate and reliable machines whose performance is known and "guaranteed" for a wide variety of tasks and operating conditions. However, machine tools are subject to many error sources that change over time, are difficult to assess, and have effects that are task specific and difficult to predict. Thus users have to resort to costly part inspection and dedicated tuning to achieve requested tolerances. Moreover, they lack capabilities to harmonize part design with machine tolerance capabilities.

Approach

The program is working with industry and academia to develop the enabling metrology, smart sensor systems, and standards to characterize, monitor, and improve machine accuracy and reliability. The research addresses 1) parameters, test methods, and standards to evaluate machine performance; 2) standardized formats and infrastructure for the exchange of performance data; 3) methods to translate performance parameters into tolerances of machined parts; 4) methods and sensor applications to monitor and improve machine accuracy; 5) methods and sensor applications to monitor and (remotely) diagnose machine condition and failure; and 6) standards for smart sensor interfaces, wireless sensor connectivity, and sensor network capability relevant to condition monitoring. Smart machine tool capabilities of increasing sophistication will be demonstrated on a turning and a machining center.



Application of a grid encoder to test and improve the contouring performance of a machining center.

Customers and Collaborators

- Aeptec Microsystems
- Agilent
- AMT
- API
- Boeing
- Caterpillar
- Endevco
- General Motors
- Hardinge
- Heidenhain
- Honeywell
- IMTI
- IQL
- Kistler Instruments
- Lion Precision
- MIMOSA
- The Modal Shop/PCB Group
- National Instruments
- NASA
- Northrop Grumman
- Oak Ridge National Laboratory
- Optodyne
- Pratt & Whitney
- Renishaw
- Southern University
- U.S. Army Picatinny Arsenal
- University of North Carolina at Charlotte,
- University of Florida
- University of Massachussets
- Unova
- VulcanCraft
- Wilcoxon

SURFACE METROLOGY

Program Manager:	Theodore Vorburger
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Email:	tvtv@nist.gov
FTEs:	9.1
Program Funding:	$891 K

Program Goal

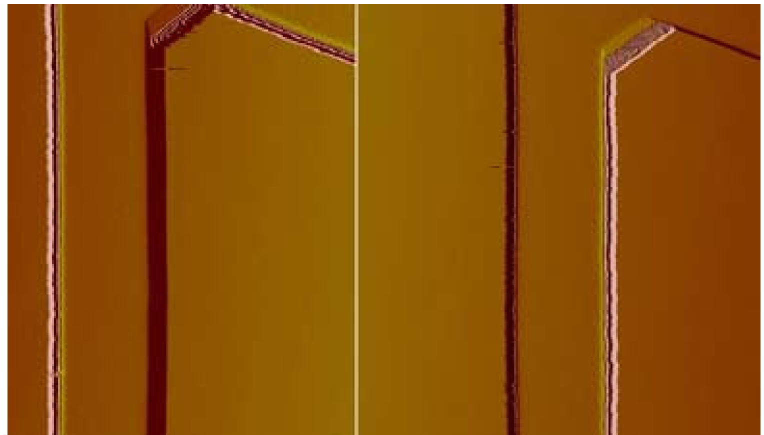
Deliver with world leading levels of uncertainty to the U.S. metalworking and semiconductor industries and to the law enforcement community the most critical measurement service or standard required by each in the field of surface and micrometrology.

Problem

The functional properties of many engineering components are affected by surface quality. Therefore, many surfaces of these products must be specified and measured for surface finish and surface feature dimensions. The health of U.S. manufacturing relies strongly on continuous improvement in the accuracy of industrial surface metrology, which in turn depends on NIST measurements with ever lower uncertainty of an increasing range of surface parameters.

Approach

We provide calibrations and tests, standard reference materials, and expertise on documentary standards committees in support of improved surface finish metrology and micrometrology in United States industry and government. We use high-resolution profiling instruments, calibrated with respect to the SI unit of length, to perform traceable measurements having low uncertainty. Using new techniques, we are continuously upgrading the accuracy of these instruments and the calibration of our master artifacts to meet developing customer requirements.



Paired data for a new image-stitching linewidth measurement approach using AFM with a nanotube tip (fabricated at NASA). The line (about 650 nm across) was developed by EEEL.

Customers and Collaborators

- American Society of Mechanical Engineers
- Boeing Corporation
- Bureau of Alcohol, Tobacco, & Firearms
- Cummins Engine Company
- IBM Almaden Research Center
- International SEMATECH
- National Institute of Justice
- Veeco Instruments
- VLSI Standards, Inc